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Original Research

Can interactive educational technologies support the link between ultrasound theory and practice via feedback mechanisms?

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Abstract

Linking theory to practice is an area of concern for ultrasound students, clinical mentors and academic staff. The link between theory and practice requires a robust clinical mentorship scheme in addition to careful curricula design considerations to improve student outcomes. The introduction of interactive technology in education provides ripe opportunity to improve feedback to students to support the link between theory and practice. A series of three interactive learning and teaching activities were designed and delivered to a PostGraduate Ultrasound cohort, after which, evaluation was performed to answer the research question: Which interactive technologies support the link between theory and practice through improved feedback mechanisms? An action research methodology was adopted involving an enquiry based literature review, planning, design and action process. Data were collected following action of three interactive teaching and learning sessions within the Medical Ultrasound cohort of 2013/2014 at Glasgow Caledonian University via a paper based questionnaire. A 100% response rate was achieved ($n = 14$). All three interactive learning and teaching sessions were considered with 100% highest point agreement to support the link between ultrasound theory and practice via feedback. Students found all three designed and facilitated sessions valuable and relevant to their learning, which in turn provided positive experiences which were perceived to support the link between theory and practice through feedback. These activities can be considered valuable in Postgraduate Ultrasound education.

Keywords: Ultrasound, education, simulation, clickers, Smartboard

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Introduction

Postgraduate Ultrasound (US) training is a time challenging and intensive period of study comprising both clinical practice placement and University-based learning. A series of assessments including paper-based examinations and a portfolio of learning is captured to demonstrate continuous professional developments (CPD) through reflective practice and experiential learning with an emphasis on practice-based learning. Yet still, the theory practice gap in transferring knowledge and understanding into clinical practice[1] has been observed as a difficulty for some students studying at Glasgow Caledonian University (GCU).

This is partially anecdotal; however, previous attrition and failure rates can be traced to clinical component issues and the inability to transfer theory into practice-based settings. Students who successfully demonstrated knowledge through pass grades in summative academic assessments failed to translate this into clinical skills thus failing to pass clinical competencies. As a new member of academic staff it became clear whilst accessing inherited learning activities that previous US students did not have the opportunity to get 'hands on' in class. The delivery of an US service and high clinical standards require an involved approach from health care professionals. Therefore, it seemed unusual that the Postgraduate students were not encouraged to learn in a familiar fashion in the classroom.

Increasing pressure for Higher Education Institutes' (HEI) to deliver a 21st-century workforce has introduced the concept of graduate attributes aimed to appeal to modern industry and employers. These attributes are core to GCU's educational ethos and therefore require careful consideration in the curriculum design process. Many Postgraduate students return to study Medical Ultrasound to diversify, increase autonomy and further their personal and professional development, all of which fall into two broad graduate attributes of:

- Employability and career development
- Personal and intellectual autonomy

These, amongst other attributes, challenge HEIs to improve quality standards and task educators to deliver high quality and fit for purpose curricula.[2] It is therefore imperative that module leaders constructively align learning tasks and environments to fulfil learning outcomes appropriately and enhance the student's opportunity to succeed.

Vocational training divided between clinical areas and HEIs pose a particular problem where there is a reliance on clinical educators to progress skills training with the primary focus of applying profession principles to practice.[3] Health care programmes operate in tandem with practice educators who are significantly involved in the competency and professional conduct accrued by trainees. There is no doubt that exposure to highly skilled professionals, clinical situations and the opportunity to apply theory to practice are crucial health care education components, and therefore HEIs produce educational directives alongside learning objectives and assessments to guide training. Yet without the participation and engagement of both students and practice educators, alongside the HEIs in a tripartite relationship, transferring 'class room' teaching into the clinical practice setting can be problematic.

Research question

Which interactive learning environments enhance the application of theory to practice through feedback mechanisms in Postgraduate Ultrasound education?

Methodology

To answer this question, an action research methodology was adopted based on the principle of continuous improvement through observation and action.[4]

Literature review

To inform the design of activities, a review of literature was performed.

Learning theory

Vocational programmes which include practical skills training generally employ experienced practice educators to provide experiential teaching opportunities to trainees. This environment lends itself to the constructivist theory of learning where active dialogue can flourish in clinical situations allowing the trainee to explore and analyse through experiences shared with experienced colleagues. Of recent times, there has been an educational steer towards a student-centred approach to learning and teaching, as evidenced recently through the introduction of the curriculum for excellence (CFE). In early year's education through to higher education, educators are tasked to involve students in their own learning and provide opportunity for students to explore learning and encourage divergent thinking. Very little criticism is evident in modern literature regarding a flexible student-centred approach. However, notably, traditionalist educators tend to teach through transfer of knowledge through didactic dialect. It is also recognised that a student-centred approach provides an open forum for students and one which may be more difficult to manage or to focus in an area of well-versed routine.[5] Previous studies report a distinct lack of empirical evidence to support student-centred constructivist models of learning and inform greater achievement from students in a teacher-directed environment.[6] Furthermore, those adopting a constructivist approach in classrooms are merely providing an environment for students and provide very little teaching.[7] Conversely, many communicate this as a fundamental misunderstanding of the constructivist learning theory which is neither teacher nor student centred, but rather learner centred. Supporters of social constructivism celebrate the notion of inquiry and engagement where learners can create, reorganise and compound knowledge using previous experience.[8,9] Many believe that supporting well planned learning environments may require more skill than lecturing intently for a prolonged period of time.[5] In general, the social constructivist theory of learning is acknowledged as an effective method for the health sciences.[5,10]

Feedback

Successful learning requires appropriate feedback. Feedback is widely accepted as a vehicle for students to make sense of their work or ideas, provide clarity and amend misinterpretations.[11] Many have formal feedback policies which staff must prescribe to, providing feedback for future learning.[12]

Interactive learning environments

The digital age of learning has seen a wide use of interactive technologies and social media used in education through response to the national e-learning strategy.[13] Universities across the UK are supporting e-learning and investing in technology to enhance learning and teaching. The Higher Education Funding Council for England (HEFCE) e-learning strategy's aim is 'enhancing learning and teaching through the use of appropriate technology' where activities must be expertly embedded with primary consideration given to pedagogy and learning outcomes.[13]

Clicker technology

Audience response systems (clickers), wikis, blogs and simulation all feature regularly in educational research studies with reported success in improving student engagement.[14–16] Previous large-scale studies have demonstrated effectiveness of the use of clickers to provide feedback to both student and teachers within large classrooms. Increased student engagement emerges as a key theme. However, very little can be drawn on the transfer of increased engagement to increased student learning.[17,18]

One study found that employing clicker technology improved class answers in a single session from 16% to 100%; furthermore a re-poll one week later established that 80% of the same cohort maintained understanding of concepts. These results deserve acknowledgment, yet further research including a non-intervention re-poll could strengthen these claims.[19] Other findings include ease of use and enjoyment with the category appraisal/learning viewed positively in relation to the use of clickers with statistical significance of at least $p < 0.02$; on the other hand, preparation/motivation delivered the least positive response. Reported disadvantages of employing clickers include staff inexperience and technological glitches.[18] However, another study reported that student ratings improved as staff became more adept at clicker utilisation.[20] Furthermore, designing the correct types of question to facilitate meaningful discussion requires creativity and time. Nonetheless, clickers successfully dovetail with group discussion and increase interactivity and engagement with peers.[21,22]

Smart board technology

No systematic reviews of smart board technology integration within HE were found, yet integration of interactive smart board (whiteboard) technology is widespread across all levels of education.[23] Reported teacher benefits include efficiency of accessing a variety of materials, while students report increased facilitation of learning (particularly when 'hands on') and visual learning opportunities.[24] Akin to most other newly introduced technologies, there is a strong emergent theme within relevant literature of 'technological naivety' or inexperience on the teacher's behalf, which can often impact student learning. It is generally accepted that smart board technology may be difficult to master, but perhaps more importantly it is acknowledged that pedagogical styles of learning must embrace a student-centred approach to maximise effectiveness.[23]

Simulated learning

Working collaboratively within inter-professional teams and complex clinical settings provides ripe opportunity to construct social knowledge based on experiences. There can be no substitute for real world problem solving from authentic experiences in ultrasound training. However, it is well evidenced that good quality mentorship and ensuring parity of learning opportunities are a challenge for programmes of learning, especially under health service financial and time constraints.[25] In response to the changing clinical environment, simulated learning in education has become an attractive and accessible commodity.[26] Simulation is generally accepted as a device that presents an imitation patient or a hypothetical environment. The integration of clinical simulation in some areas of education has become mandatory to demonstrate foundation competence prior to extending into the clinical field.[27] A systematic review and meta-analysis of technologically enhanced simulation for health care education literature was performed in 2011.[28] This study included data from 609 eligible studies following strict inclusion and exclusion criteria. A large sample of 35,226 trainees were considered and when compared with no intervention, trainees undergoing simulation of various types, such as computer-based simulators, high fidelity simulators and plastic models, recorded outcomes of large effect for knowledge, skills and behaviours. Moderate effects were noted in patient-related outcomes. This comprehensive peer-reviewed study corroborates previous systematic reviews in this field, where large outcomes with statistical significance were determined, where simulated learning was compared with no intervention.[28–31] Yet, still there is a distinct lack of empirical data to distinguish whether simulated learning transfers to clinical practice skill.[32,33] A recent scoping paper emphasises that even though simulation is hugely popular with both students and facilitators, no clear guidance is available on how to successfully embed activities into the curricula, furthermore, primary research is required to gauge the transferability of simulated learning into the clinical environment.[34]

In summary, studies investigating interactive educational technology generally agree that key considerations for use within teaching and learning include relevant alignment, planning, design and experience.

Action

Following the review of literature and in discussion with a group of critical friends, an action plan was developed to address the research question, resulting in the design and implementation of three interactive learning and teaching activities within the Post-graduate Medical Ultrasound programme of learning at Glasgow Caledonian University in session 2013/2014.

Clicker session

A clicker session was designed and delivered to the Clinical Ultrasound module cohort. All students were introduced to clicker technology with an opportunity to test the technology for scenarios of a one-answer response and a two-answer response. The clicker quiz session included a total of 15 questions which were carefully designed to include previous subject content from taught sessions, directed learning or common clinical practices observed in the clinical practice education setting. These areas were introduced prior to the session with reference to formal module learning objectives. Questions were constructed in a variety of ways including true and false, multiple choice and open ended. Where multiple choice answers were included, attention was given to the wrong answers to maintain relevance with the possibility that this may engage students in discussion around the question topic. Ultrasound images were included for review to reflect diagnostic appraisal and image interpretation in addition to authentic practice issues.

Smart board tutorial

A smart board tutorial activity was designed and delivered within a tutorial session within the Principles of Practice in Medical Ultrasound module. This session was preceded by directed learning in the form of pre-reading, equipment pre-set analysis and physics and technology key note lectures. Students were given a verbal introduction to the smart board functionality (how to scroll, write, erase and save). Students were arranged into small groups of three and asked to complete a series of questions or scenarios presented via the smart board. The questions involved

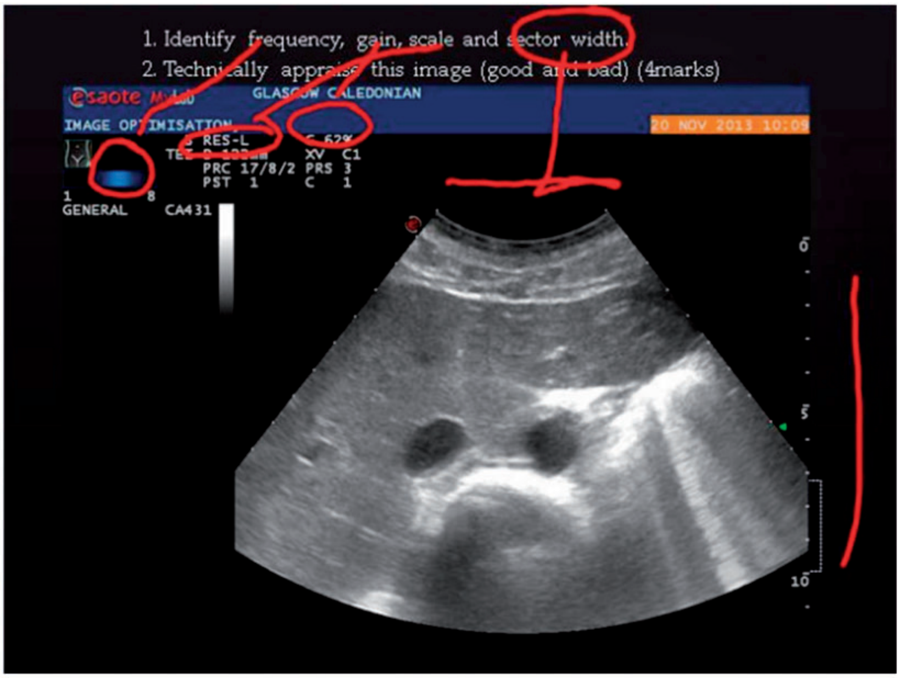

Figure 1 Student Smartboard activity

problem solving tasks through identification of image technical factors and deficiencies. Students were encouraged to overwrite images or areas of consideration and critical appraisal (see Figure 1).

Simulation

A group transvaginal ultrasound simulation session was developed and delivered. Clinical scanning had commenced prior to this session, therefore students had gained foundation knowledge on scanning orientation, anatomical structures and common ultrasound appearances. Simulation was performed using the MedaPhor transvaginal ScanTrainer (MedaPhor Ltd, Cardiff Medicentre, Cardiff, Wales) which is a virtual reality computer-based haptic device that imitates clinical scanning using live scan data from real patients.[35]

Students observed an introductory virtual guide of the ScanTrainer, which was supplemented by the facilitator in the basic functionality of the device. Clear learning objectives were verbalised yet students were made aware that this was a semi-structured session which was open to flexibility dictated by student needs. Whilst one student performed scanning through the simulated ScanTrainer, the remainder of the group watched the live simulation scan feed on a large wall-mounted LCD television. Students were asked to direct the scanning student to various anatomical regions in different imaging planes (initially dictated by the facilitator but later leadership was passed to students) and describe the associative anatomy and/or pathology and challenges they encountered. Paper hand-out tasks linked to the scanning subject matter were distributed throughout the session to provide further opportunity for students to discuss theory and link to practice.

Methods

A paper-based questionnaire was devised to obtain student opinion on the learning activities supporting the link of theory to practice through feedback. This method of inquiry was selected due to the ease of use for participation and a limited timescale. Twelve questions were constructed, informed by relevant literature and themes emerging from previous studies, including prior use of technology, preferred teaching approach (key note lectures, interactive technologies, peer learning, tutorials or other) and contribution of realistic clinical scenarios. Questions were based on Yes or No answers and a five-point Likert scale with terms strongly disagree, disagree, neutral, agree and strongly agree and included areas for expansion of opinion to evaluate students' perceptions of each activity.

Data analysis

Evaluation of quantitative and qualitative data was performed via simple descriptive statistics and activity analysis to answer the research question: Which interactive learning environments enhance the application of theory to practice through feedback mechanisms?

Findings

Students from two modules provided data for this study:

- Principles of Practice in Medical Ultrasound – $n = 9$
- Clinical Ultrasound Module – $n = 8$

A 100% participant response rate was attained following each of the sessions and can be used to represent student cohort opinion.

Clicker technology analysis

Students had no previous experience of clicker technology, despite this, all students found clickers easy to operate, a finding supported in previous studies.[15,36] This could be attributed to the brief introduction and test of technology prior to the learning activity or simply attributed to the fact that most students nowadays are digital savvy operators and the technology itself has simple functionality. Previous literature reports technological nuances as a barrier to student learning, yet this is often due to the facilitator's operation or lack of experience in conducting sessions with new technology.[18] This session had been planned and rehearsed and was delivered free from technological glitches. It cannot be assumed, however, that students would respond similarly if the class was disrupted due to technical failure or the inability of the facilitator to operate the system effectively.

All students recorded highest agreement that the clicker learning environment was both interesting and relevant, demonstrating that students found this particular activity of value. As previously reported, learning technologies are popular with students but are often misplaced within the curricula with a minority notion that clickers are a bit of a novelty and therefore may bear little significance within teaching and learning.[37] The findings from this study support that constructive alignment of activities employing clicker technology can be both appealing and have meaning. Constructive alignment is considered as the alignment of teaching and assessment which supports intended learning outcomes.[38] This is a crucial curriculum development task which ensures students have clear learning objectives, realistic outcomes and have the learning activities and assessment to support success. Many believe that this is a labour-intense approach to learning and teaching and this is an area out with the foci of this particular project, yet arguably this is the area where time should be spent to maximise effective education.

All students either agreed or strongly agreed that the session was useful in incorporating clinical scenarios and provided students with instant feedback. All students strongly agreed that the learning activity supported the link between theories and practice with facilitator feedback the preferred mode, followed by peer and technological feedback respectively. Lecturers/facilitators are often viewed as the most valuable resource to students, particularly as curricula are densely laden and teaching capacity continues to decline and more online learning emerges. This particular learning environment enabled students to test their knowledge, discuss the subject and gain immediate lecturer support. A small student–staff ratio may have increased student feedback satisfaction through increased opportunity to ask questions, yet clicker learning activities can be applied to large cohorts and have been reported with reasonable success.[18]

One student proposed:

> 'more interactive teaching-this allowed us to ask about different aspects that may crop up around the topic and get instant feedback from the lecturer'

Another student commented that:

> 'peer feedback really helped me understand I am thinking the same'

This demonstrates positively that this individual found assurance through peer interactions. Small group teaching provides an opportunity for learners to scope their ability compared to the level of their peers.[11] While clicker technology can facilitate discussion throughout groups, it should be noted some students may not wish to share their ideas openly.

A student provided:

> 'I'm glad it was anonymous – there are some areas I really need to work on'

This statement indicates this student received effective feedback on their learning progression (which they may or may not address) and appreciated anonymity. This is an important area to address with classroom activities. Clicker activities can become the 'raised hands' within the class, which offer a safe environment to enhance learning through instant feedback and participate in learning activities without fear of embarrassment from under achievement. This represents only one student within the group and is inconsistent with the findings from a previous study, which recorded anonymity as one of the least helpful features of clicker technology.[39] Regardless of preference on anonymity the prospect of engaging without finger pointing can be considered widely beneficial and inclusive.

Smart board analysis

The majority (78%) of students had not used smart board technology previously; yet only one student reported that they found the technology difficult to use explaining that it:

> 'jumps about a bit and the pen has a time lag'

and continued:

> 'it was a little difficult to write on the board and move slides as I haven't used it before'

All students selected the highest point of agreement on supporting theory to practice via feedback and documented with highest agreement that the smart board activity was interesting, relevant and of value. This is likely due to the pertinent subject area but also the group activity which elicited meaningful peer interactions. Through introduction of material via the smart board, students actively discussed broader themes around the clinical practice equipment they use, their functionality, different manufacturer terminologies and ways in which they observe experienced practitioners use the ultrasound technology. Students openly offered advice, opinion and actively participated by over writing, editing and sharing ideas using the smart board. These observations are encouraging and all students selected the highest point of agreement on supporting theory to practice via feedback. Interestingly, one student provided a neutral selection when asked if the smart board activity provided instant feedback. A further two students agreed and the remainder of the cohort strongly agreed – with one student extending that it offered the:

> 'opportunity to give it a go see what everyone else thinks then the lecturer can confirm or correct'

The term 'instant feedback' may be interpreted differently; this activity was peer focussed with facilitator support. In contrast to the clicker session, the technology itself did not provide feedback via visual answer statistics. It may be considered that this student did not identify with peer or facilitator feedback as being 'instant'. Extensive research has been conducted into demystifying the student perception of feedback and yet there is a persistent disconnect between the views of student and teacher; this in part could explain this student response.

Simulation analysis

All students found the ScanTrainer easy to use and full consensus with highest agreement was that it was an interesting, relevant, useful session, which provided feedback supporting the link between theory and practice.

Students particularly enjoyed the opportunity to discuss scanning issues within the group:

> 'great to discuss technical issues with people other than your mentor'

and further supports the perceived importance of peer feedback. Practice education may involve mentorship from a variety of staff or may be restricted to a single supervisor. One student provided additional comments that:

> 'viewing other people's scanning methods is a great help'

This again provides evidence that students perceive the feedback from simulated activity to be of value. A strong emergent theme from student comments was that the simulation activity provided the time and space to work through problems and technique together in an environment supportive and safe from real practice situations.

> 'not always appropriate for trainee's to take time in real life scenarios'

There is a growing body of evidence to promote simulated learning activities, particularly in ultrasound education and that student confidence is enhanced through the simulated learning environment.[40,41] Five students provided additional open comments including:

> 'this is going to help more time 'in flight' in work'

> 'practising without time pressure and loads of assistance is just great'

Although there remains to be a lack of evidence demonstrating the translated competency skills from simulated activity into clinical practice, students' opinions reveal that problem areas could be re-visited, and learning achieved was reinforced which would suggest increased confidence when compared to no intervention. All students responded positively to the hands-on learning environment and one student added:

> 'good to get paper hand-out material to aid discussion while others were on simulator'

All students viewed the simulation session highly positively.

Limitations

Limitations of this study include a small sample size from the Medical Ultrasound Programme. A larger population would increase the generalisability of these findings. Supplementary data collection methods such as focus groups and interviews would have enhanced the richness and volume of data included in this study. This project was performed within a limited and restricted timescale due to competing priorities.

Conclusion

The findings from this study support an inquiry-based social constructivist setting for students to construct complex understanding and recognise strengths and limitations alongside their peers. The themes emerging from the series of interactive technology sessions, designed to improve feedback to support the link between theory and clinical practice, appear to centre around two key areas of subject relevancy and peer feedback.

All three learning activities were considered successful with consensus highest agreement scores in providing feedback to support the link between ultrasound theory and practice. Despite students' unfamiliarity, the inclusion of these interactive educational technologies was considered valuable within the Postgraduate Ultrasound programme.

The positive findings from all three activities provide initial evidence to support the continuation of interactive technologies in the Medical Ultrasound Programme of learning. Minor adjustments will be made to improve sessions based on student feedback and published literature.

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